



Lattice Confinement Fusion Gas Cycling Experiments

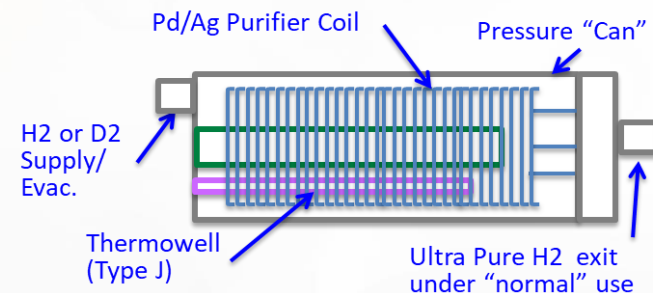
ARPA-E Workshop on Low-Energy Nuclear Reactions
October 21–22, 2021

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J-M Gas Cycling Experiments: Description

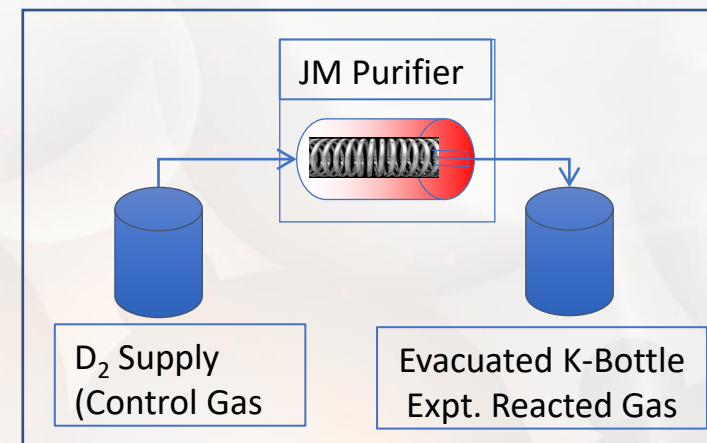
High flux of D through Pd/Ag hydride system:

- Test Article: Johnson-Matthey (JM) hydrogen purifier
 - Hydrogen purification accomplished by gas diffusion across Pd/Ag Tube
- Inspired by electrolytic wet cell experiments and LENR claims, G. Fralick (1989) used JM purifier to load Pd with D₂ since it's easier than loading D₂ during a wet cell experiment; looked for neutrons and heat release
 - Very little neutrons above background observed
 - Observed temperature rise of 17 °C in 15 sec unloading D₂ but not with H₂
- Experiments in 2014 & 2018: pressurized cycling of D₂ gas produces heat & surface transmutations on PdAg tubing; evidence of LENR
- Experimental protocol:
 - Heat JM purifier tube bundles to < 400°C (ideally between 375°C & 400°C) to maintain structural integrity of Pd/Ag tubing and heal cracks on the tube
 - Load with D₂ gas to given pressure on inner/outer sides of Pd/Ag coils
 - Unload: Rapidly evacuate to vacuum sink, resulting in high flux of trapped D
- Inputs/Outputs:
 - Resistance heater used to raise temperature of the Pd/Ag tubing
 - Thermocouples placed on parts of PdAg coil, the inner SS can, and heater
 - Pyrometer aimed at sapphire window to monitor overall temperature
 - Materials analyses of unexposed and exposed PdAg tubing



Schematic of H2 Purifier

Anomalous Heat observed: flux of Deuterium (D₂);
Temp Rise: 2009: °5 C; 2012: 25°C during unload



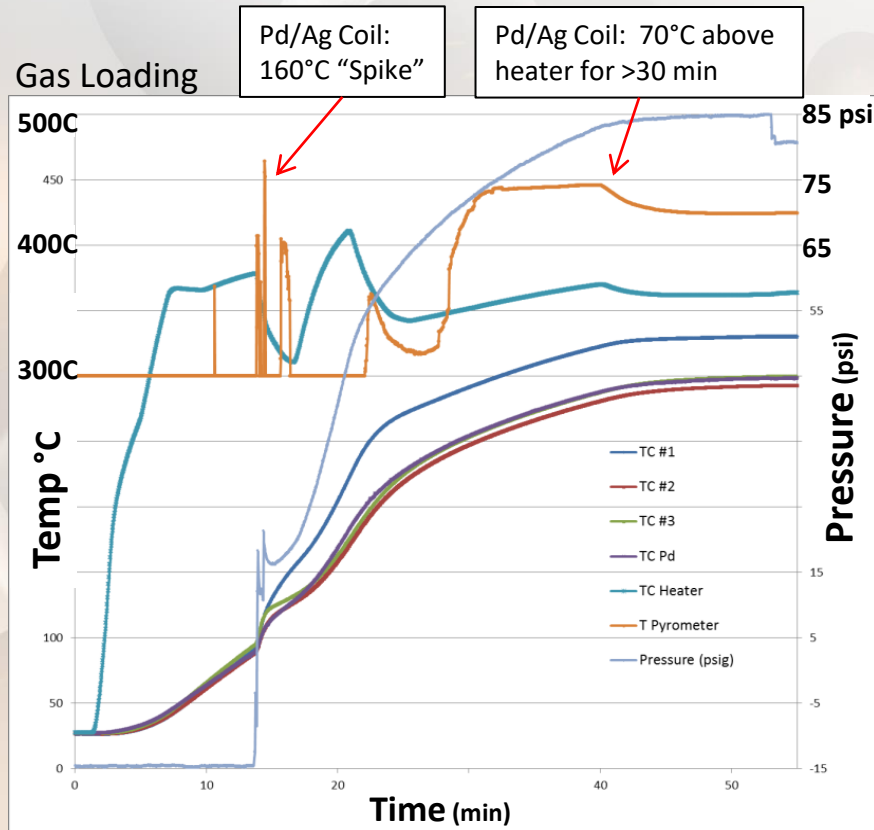
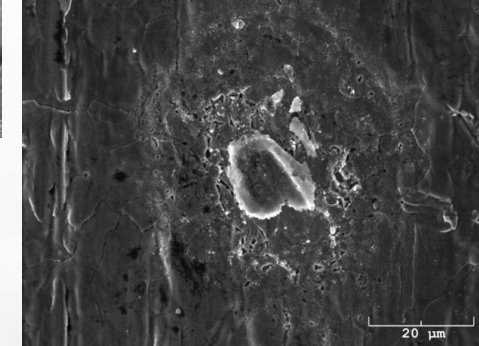
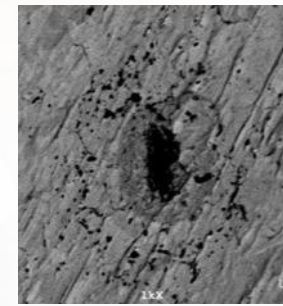
Initial work during original 1989 gas cycling experiments inspired other researchers such as Bin Liu and J. P. Biberian to investigate the excess heat anomaly.

- B. Liu excess heat (2006): 3.5 W
- Biberian excess heat (2007): 3 W (calorimeter)

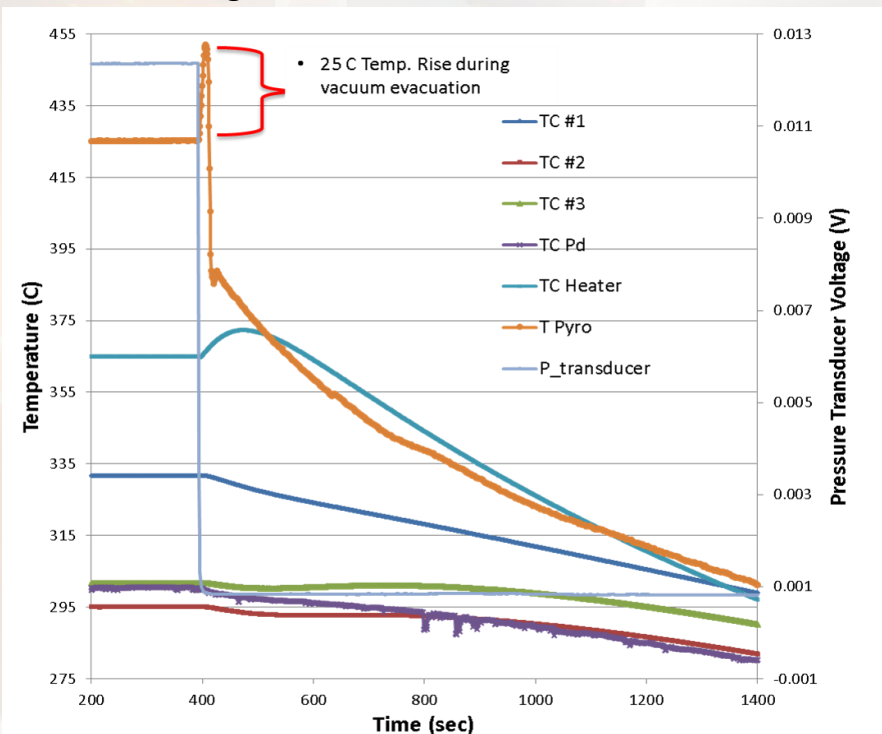
J-M Gas Cycling Experiments: Data (2014)

High flux of D through Pd/Ag hydride system:

- Thermocouples showed anomalous heat release during experiment
 - During D₂ cycling, temperature rise occurred almost 100% present
 - During H₂ cycling, temperature rise less often than during D₂ cycling
 - During He cycling, temperature rise never occurred
- Scanning Electron Microscopy showed areas of molten looking spots and craters
 - Palladium melts at 1560 °C and silver melts at 962 °C yet system heater was kept under 425 °C



Gas Unloading



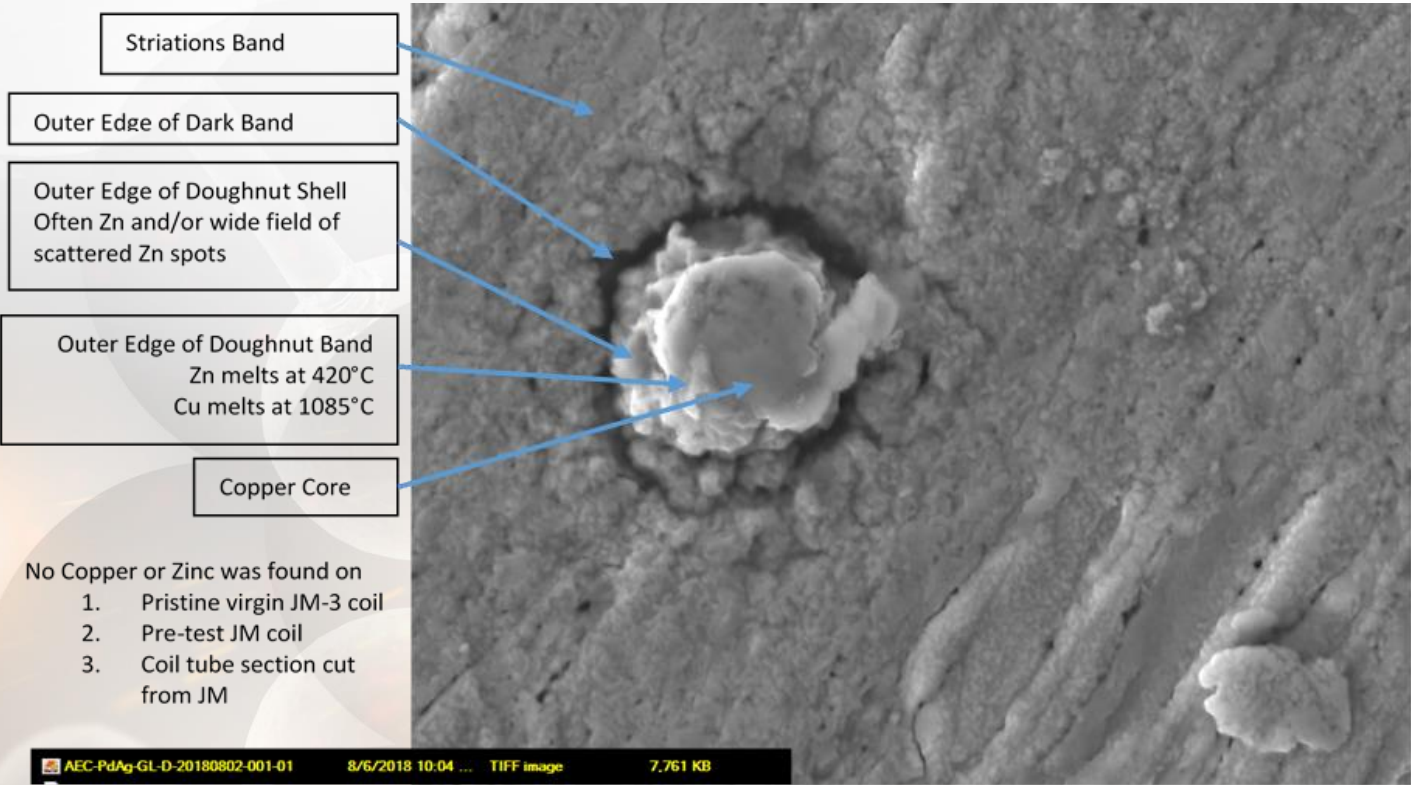
Joule-Thomson effect would induce cooling during gas evacuation instead of a 25 °C temperature rise

Repeat of temperature rise during D₂ gas unloading

- 1989: 17°C temp rise in 15 s
- 2014: 25°C temp rise in 4 s
- 2018: 12 °C temp rise in 45 s

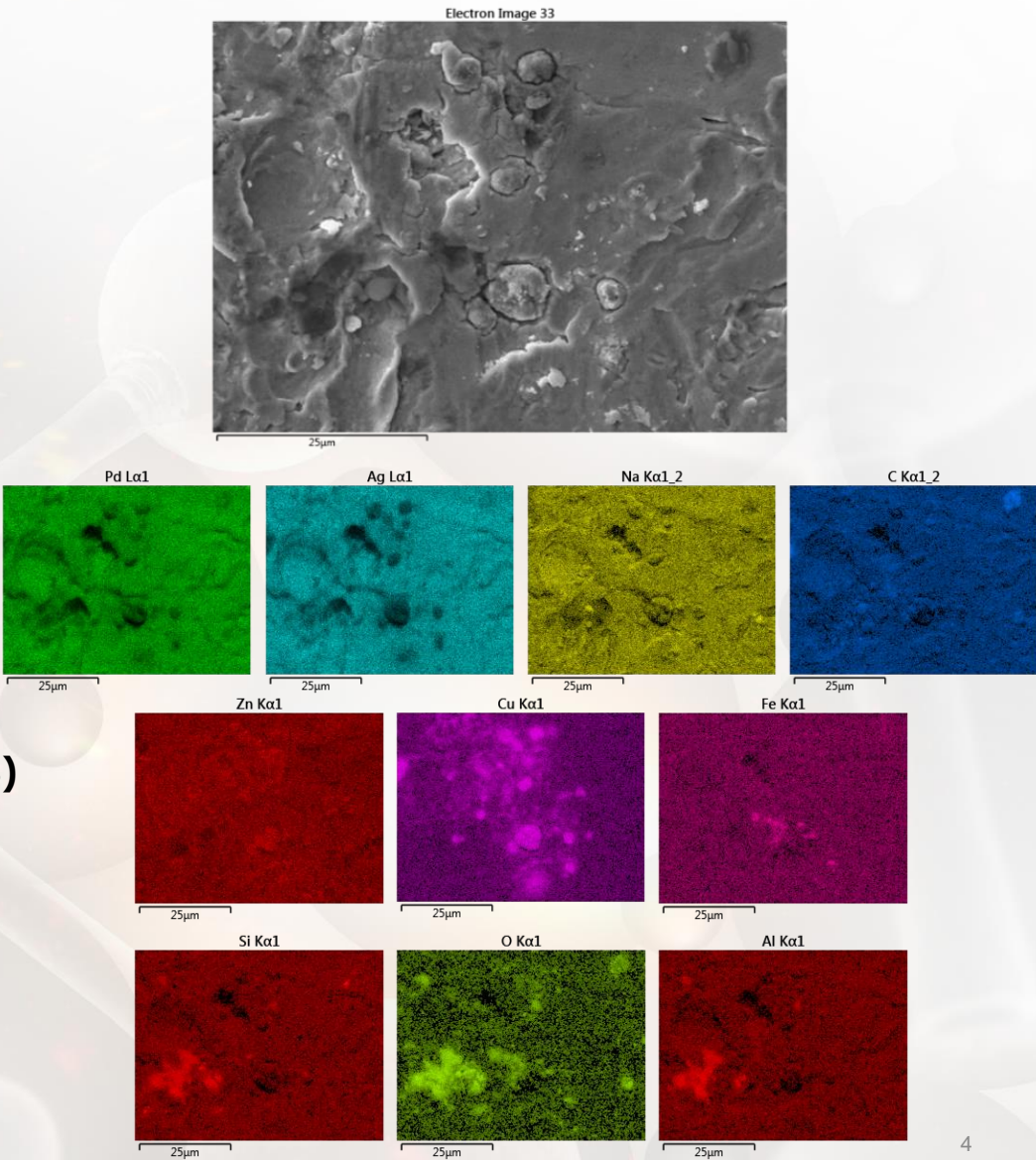
Note: Pyrometer was not used in the 2018 experiment.

J-M Gas Cycling Experiments: Data (2018)



Scanning Electron Microscope/Energy Dispersive Spectroscopy (SEM/EDS)

Observed areas that look
melted or crystalized.



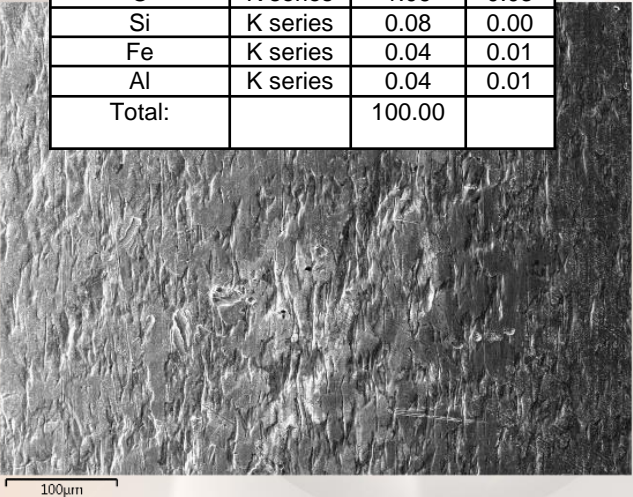
J-M Gas Cycling Experiments: Data (2018)

High flux of D through Pd/Ag hydride system:

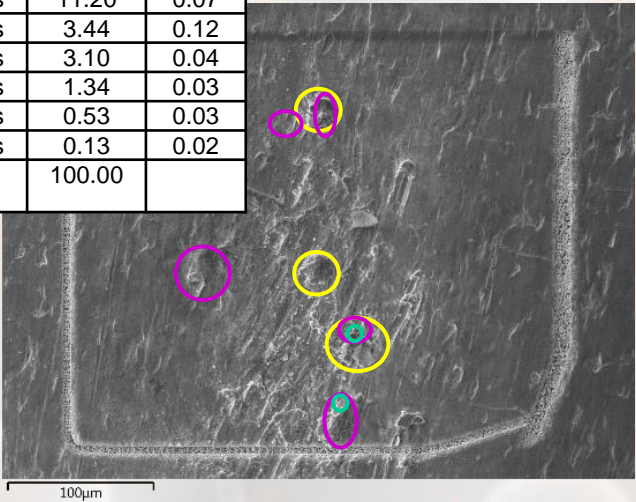
- ICP-AES: Elemental bulk analysis of PdAg tubing
 - Elevated levels of Cr, Cu, Fe, Mn and Zn detected in the exposed PdAg tubing
- SEM/EDS: Elemental surface analysis of PdAg tubing
 - Spots of Fe, Cr and Cu on top of the PdAg alloy with overall spread of Zn on exposed PdAg tubing compared to unexposed PdAg tubing with mostly Pd, Ag and trace of Fe present.
- ToF SIMS: Isotopic surface analysis of PdAg tubing
 - Areas of ⁶³Cu, ⁶⁴Zn, ⁵⁶Fe, and ⁵²Cr

Scanning Electron Microscope/Energy Dispersive Xray Spectroscopy

Element	Line Type	Wt%	Wt% σ
Pd	L series	72.47	0.04
Ag	L series	26.31	0.03
O	K series	1.06	0.03
Si	K series	0.08	0.00
Fe	K series	0.04	0.01
Al	K series	0.04	0.01
Total:		100.00	

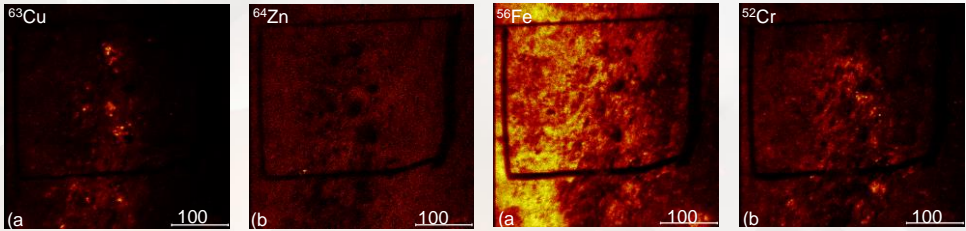


Element	Line Type	Wt%	Wt% σ
Pd	L series	62.95	0.14
Ag	L series	17.32	0.12
Zn	K series	11.20	0.07
O	K series	3.44	0.12
Cu	K series	3.10	0.04
Fe	K series	1.34	0.03
Ni	K series	0.53	0.03
Cr	K series	0.13	0.02
Total:		100.00	

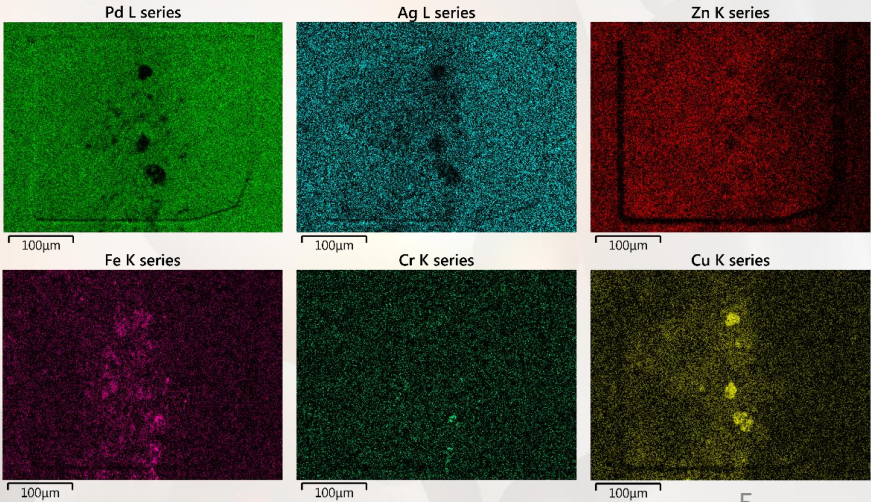


Inductively Coupled Plasma Atomic Emission Spectroscopy				
Element	Pd25Ag Bulk Results			Units
	Control/Unexposed	Exposed	Δ	
Ag	25.0	24.9	-0.1	wt%
Pd	75.0	75.1	+0.1	wt%
Al	30	30	0	ppm
Cr	Not detected	2	+2	ppm
Cu	20	140	+120	ppm
Fe	20	40	+20	ppm
Mg	1	1	0	ppm
Mn	Not detected	0.5	+0.5	ppm
Na	2	2	0	ppm
Pt	105	105	0	ppm
Si	40	30	-10	ppm
Zn	Not detected	285	+285	ppm

Time-of-Flight Secondary Ion Mass Spectroscopy

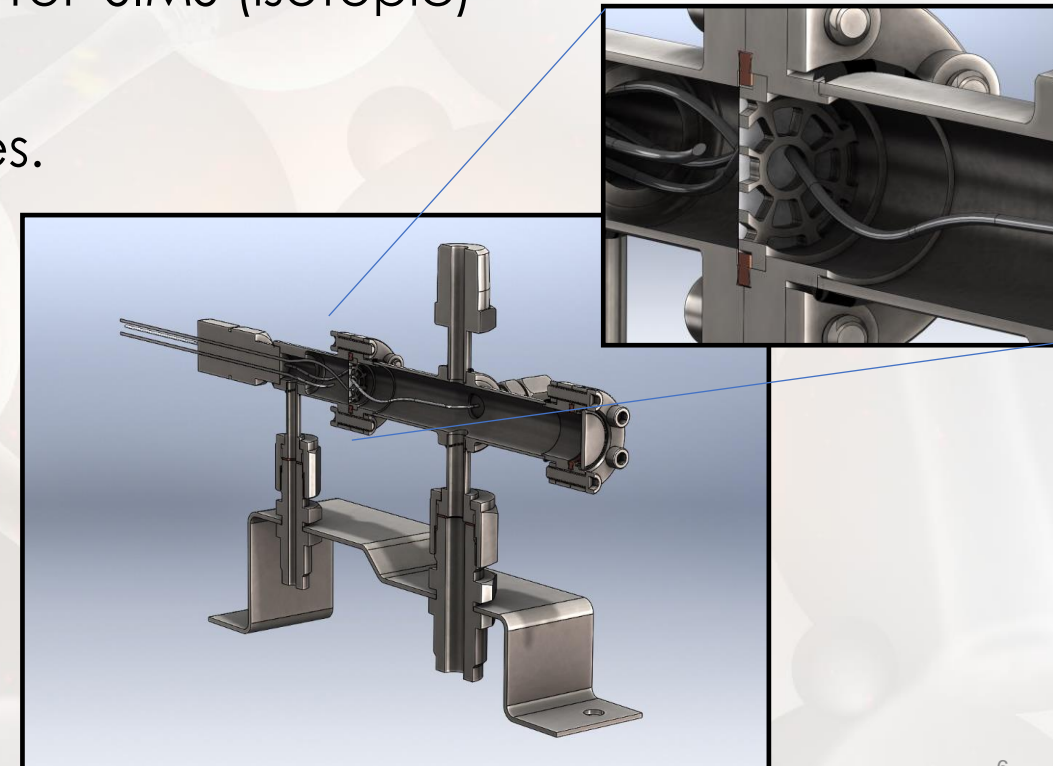


SEM/EDS



Assessment of needs

- Need to rule out contamination of PdAg tubes with other materials within the JM gas cycling system; stainless steel being transferred?
- JM system really designed for hydrogen purification
 - Need pressurized system specifically designed to track material changes and allow for other materials to be cycled with reaction gases
- Need more data of before vs after condition of PdAg
 - Continue ICP-AES (bulk), SEM/EDS (surface), and ToF-SIMS (isotopic)
- Need better measurement of excess heat
 - Run with calorimetry in addition to thermocouples.
- Repeatability and Scalability
 - Need to have multiple runs with same conditions
 - When repeatability mastered, begin scaling up
- Further investigation of d-Pd fusion-fission theory
 - Gas analysis of captured/cycled D₂ gas
 - Additional SEM/EDS and ToF analysis of samples

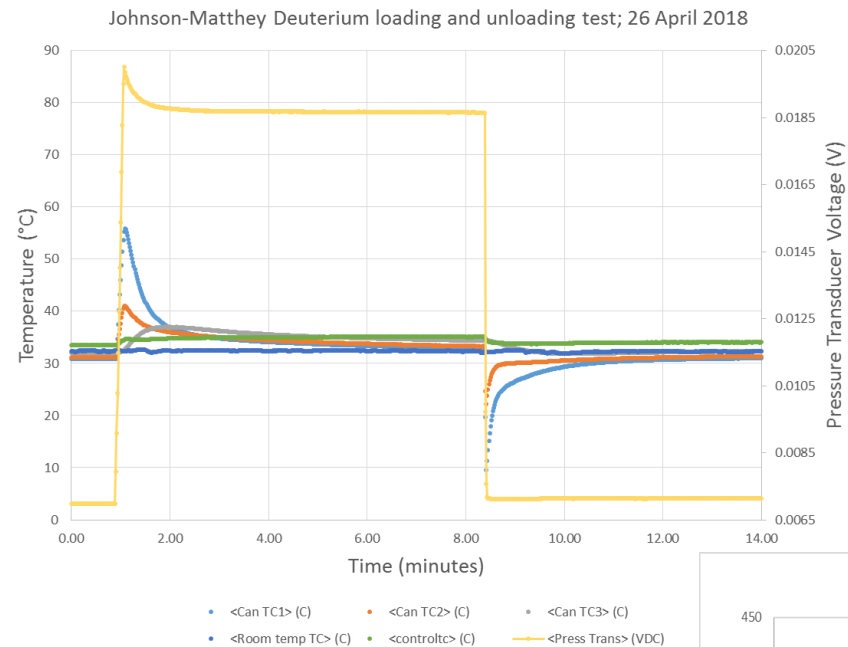


B. Liu, Z. M. Dong, C.L. Liang, and X. Z. Li, "Nuclear Transmutation of a Thin Pd Film in a Gas-loading D/Pd System", *J. Condensed Matter Nucl. Sci.* 13 (2014) pp. 311-318

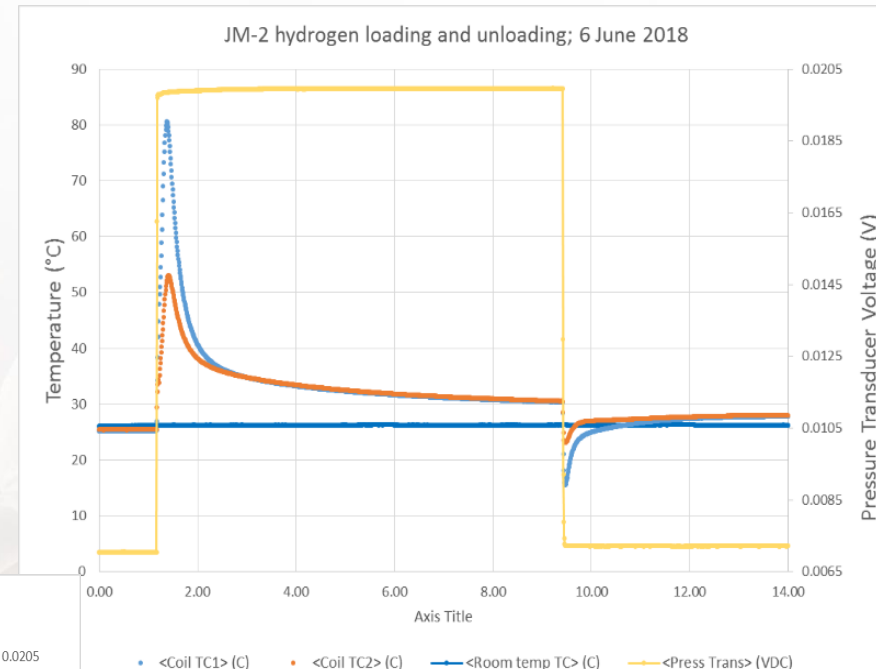


Backup

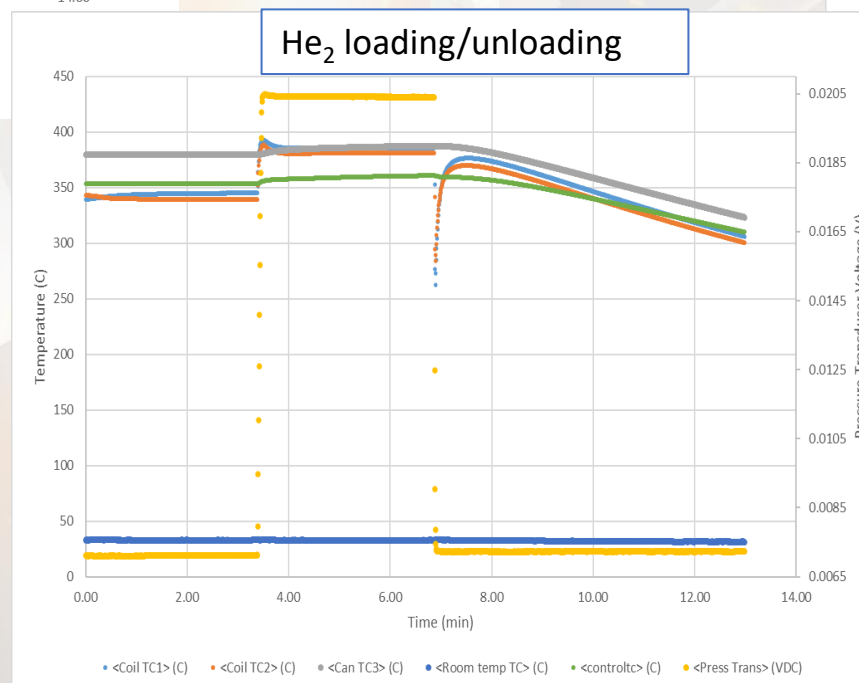
Temperature vs Time Data from 2018 JM experiment



D₂ loading/unloading



H₂ loading/unloading



Additional area with transmutations (2018)

